PREFERENCE OF TRAVELLERS FOR SUSTAINABLE TRANSPORTATION PLANNING OBJECTIVES IN KLANG VALLEY, MALAYSIA

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ABSTRACT

Achieving sustainable transportation is a global aim today. However, the actual implementation of sustainable principles is severely challenging the decision-makers. Various efforts attempted to reduce the ownership of private vehicles have not been fruitful. The failures may be attributed to the fact that public transport services are unable to provide effective travel needs as offered by cars. This paper uses stated preference method to examine the travellers' preferences for a set of hypothetical sustainable transportation strategies over different transport options. Factors evaluated in this study cover three basic sustainability dimension namely social, economic and environmental factors. A disaggregate choice model based on the data collected was developed. This model would provide better understanding of travel demands and their constraints in Klang Valley, Malaysia. In addition, analysis to determine the value of time was also conducted and these findings have been found to be useful for future planning and development of sustainability measures.

1. INTRODUCTION

Since the Brudtland Report was tabled in 1987 (WCDE, 1987), the concept of sustainability which was further culminated during the Earth Summit (1992) held in Rio de Janeiro has been increasingly gaining attention among the policy makers and researchers (Andriantiatsaholiniaina et al., 2004). Many definitions on different subject have been developed (Barbier, 1987, WCDE, 1987, Common and Perrings, 1992, Pearce et al., 1989). Among them, one as defined in the Brudtland Report is "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCDE, 1987).

Transportation plays an important role in sustainable development, since transport activities tend to be highly resource intensive and have numerous external costs. For example, the transportation sector consumes more than 60% of all petroleum products globally, despite efforts by many governments to encourage the substitution of other fuels (NRTEE, 1997). The concept of sustainable transport system covers varies of issues. Banister (2000) in his report addressed seven key issues as a result of transportation activities. They are as follows:

(i) Congestion - An average, speeds in some cities have been decreasing by 5% per decade (EFTE, 1994).
(ii) Increasing air pollution - According to the standard recommended by WHO (1997), air quality in many cities have been exceeded.
(iii) Traffic noise – It is estimated that about 15% of the population in developing countries are exposed to high levels of noise (OECD, 1995).
(iv) Road safety – Around the world, there are 250, 000 deaths and 10 million of injuries resulted from accidents (Downey, 1995).
(v) Degradation of urban landscapes.
(vi) Use of space by traffic.
(vii) Global warming – Transport accounts for 25% of CO_2 emissions.

There are many definitions on sustainable transportation. A sustainable transport system as defined by The Centre for Sustainable Transportation (Gilbert and Tanguay, 2000) is as follows:

- Allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.
- Is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development.
- Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes while minimizing the impact on the use of land and the generation of noise.

The progress of sustainable transportation is in fact very unsatisfactory (Ziestman et al., 2003). The concept has been regarded as one of the most arguable but least implemented concept in urban and transportation planning (Lindquist, 1998). Among the problems identified are inadequate understanding and recognition of increasingly important social, economic, environmental and public policy issues, short of quantified measures that can be used for monitoring and decision making as well as lacking of co-ordination between decision-makers, planners and other stakeholders (Ziestman and Rilett, 2000).

The key variables embrace in sustainable transportation concept are accessibility for all, social equity (the poor and the disadvantaged) and ecological sustainability. Promoting public transportation is a way to reduce the use of private cars in urban and hereby the adverse impacts of transportation (Banister, 2000). Increase of transit use is definitely associated with overall sustainability. A study conducted by Sinha (2003) shows that a 10% increase in transit boardings per capita per year could decrease transportation energy consumption per capita per year by about 1,700 million joules or a 10% increase in the transit share of work trips can decrease CO_2 emissions per capita per year by about 130 kg. To achieve social equity, Osula (1998) notes that through government subsidization, the travel expenditure burden of the poor and disadvantage can be eased. Nevertheless, it is seen that the statistic of car ownership is still increasing in every part of the world and the trend is moving away from sustainability.

The CfIT (2001) which is one of the relatively few studies to examine the attitudes of public transport users, pedestrians and cyclists as well as car users noted that half of the population would reduce travelling by car if the local bus services were better, a third if local rail services were better, and a quarter if local conditions for walking were better. Surveys have also proposed that a general dissatisfaction with the price, safety and reliability of public transport and a tendency to exaggerate problems with staff attitudes, frequency, availability of seats, cleanliness of vehicles, fast, comfortable, convenient and affordable services (Bonsall et al., 2005).

2. PROBLEM STATEMENT

Klang Valley Region spans across approximately 2,843 square kilometres. The entire region of Klang Valley constitutes of Gombak District, Hulu Langat District, Federal Territory of Kuala Lumpur, Klang District and Petaling District. The total population in Klang Valley has exceeded 6 millions in year 2006. Being the epic-center of economic growth for the country, Klang Valley is the fastest growing and vibrant region.

The public transport services in Klang Valley are served by rails, buses and taxis. Two Light Rail Transits (STAR and PUTRA LRT), KTM Komuter service and monorail system provide intra-city travel facilities. The bus service main provider, Rapid KL currently operates 161 bus routes with 908 buses in operation. Together with more than 13000 taxis in Klang Valley, the relevant authorities strive to provide quick, affordable and comfortable travel options. Despite the improvements to the public transport services, statistics show that from 1985 to 1997, the percentage of public transport modal share has declined from 34.3% to 19.7% (CHKL, 2003). These low public transport riderships are mainly associated with the inconvenient, inefficient, unreliable and uncomfortable services (Kiggundu, 2005). According to a recent study initiated by Syarikat Prasarana Nasional Bhd (SPNB) (The Star, 2006), there were 2.2 million private vehicles moving into the city daily. The excessive influx of private vehicles into Klang Valley has also brought the adverse impacts such as traffic congestion, air pollution that creates considerable pressure on the road network systems. It was estimated that 80 percent of the pollutants came from motor vehicle sources (Yahya and Sadullah, 2002). The traffic congestion condition in city centre has continued to deteriorate. A study by

Barter (1999) found that average public transport speeds in the Klang Valley are only 16km/hr compared to 26 km/hr in Singapore and 28km/hr in Hong Kong (Barter, 1999). In terms of traffic fatalities, it was recorded that there were about 4.3 accident fatalities case for every 10, 000 registered vehicles (Marjan et al., 2007).

Concerns over the low public transport riderships and sustainability of transportation in Klang Valley have caught the attention of various decision makers, researchers and planners. Countermeasures include new LRT extensions to congested areas, fare ticket promotion, increase service frequencies, exclusive bus lanes and others. However, the demand on the public transport is still not encouraging.

3. STUDY VARIABLES

Any sustainable transportation policy would not success if the policy makers do not understand traveller's demand and choice. The task to identify the most influencing factors is thus a challenging task. Based on thorough review of literature and pilot survey, eight variables were selected to represent the sustainable transportation system which envelops three major dimensions: economic, environmental and social. Figure 1 shows the framework and study variables of this study.

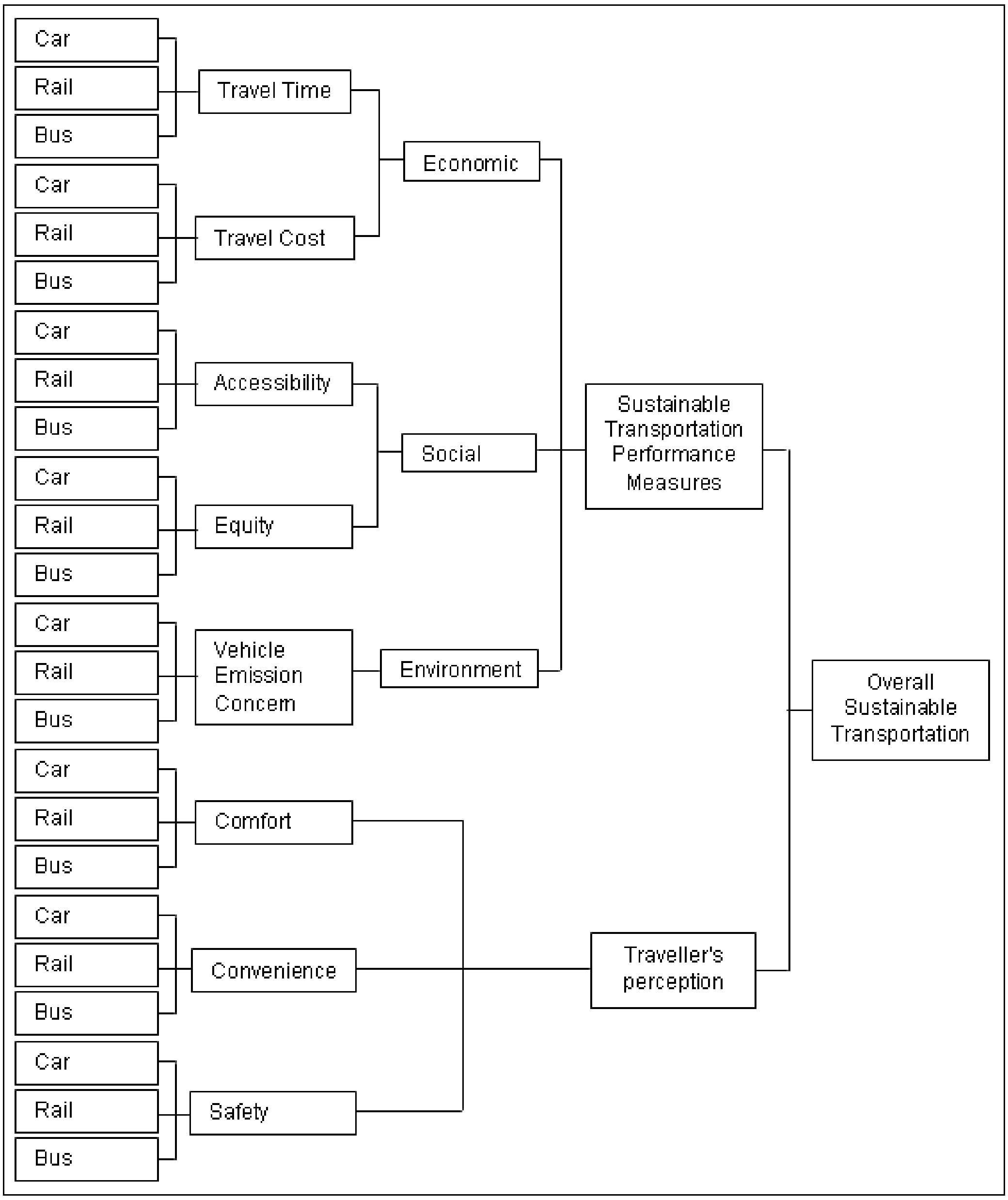


Figure 1: Study Framework

4. SURVEY DESIGN AND METHODOLOGY

To explore the effect of different policies on traveller's choice, stated preference (SP) approach was employed. SP experiments show a set of choices in relative to other modes of transport. Table 1 presents policy tools designed for this study. Each policy tool has three levels. Headway, walking distance to public transport service, comfort and convenience are not applicable to car users. The reason comfort and convenience level not tested on car users is that car is often viewed as more comfortable and convenience as compared to public transport. Travel objectives in this case refer to the number of destinations that are able to be reached within 3 hours while environmental awareness addresses the present air pollution level due to vehicular.

Table 1: Attributes and levels used for the mode choice showcards

Attribute	Mode		
	Car	Bus	Rail
IVT	30, 45, 75 min	50, 60, 75 min	15, 20, 30 min
Headway	-	5, 15, 30 min	4, 10, 15 min
Walking distance to public transport service	-	100m, 250m, 450m	100m, 250m, 450m
Petrol	1.60, 1.80, 1.90 per liter	-	-
Parking	RM 3, 5, 12 per entry	-	-
Toll	RM 0, 4, 5 per day	-	-
Travel objectives/ accessibilty	3, 4, 5	3, 4, 5	3, 4, 5
Environment awareness	Low, Medium, High	Low, Medium, High	Low, Medium, High
Security level	Low, Medium, High	Low, Medium, High	Low, Medium, High
Comfort level	-	Low, Medium, High	Low, Medium, High
Convenience level	-	Low, Medium, High	Low, Medium, High

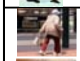
In this SP survey study, eight selected sustainable transportation attributes were tested over three modes of transportation which are car, bus and rail. This factorial design for all the attributes: 7^3 (car) x 10^3 (bus) x 9^3 (rail) has resulted in 2.5 x 10^8 combinations. It is impossible to carry all the combinations in survey. Thus, confounding factorial design was adopted. Confounding factorial design is a technique for arranging a complete factorial experiment in blocks, in which the block size is smaller than the number of treatment combinations in one replicate (Montgomery, 1997).

Table 2 summaries the fractional factorial design. For illustration purpose, consider car mode with 7 attributes at 3 levels (3^7) and is represented by 0 (low), 1 (intermediate) and 2 (high). To reduce the number of combinations, 3^{7-3} or also known as $\frac{1}{3^3}$ fraction is chosen. This fraction needs 4 independent generators and the remaining 3 generators are 3-factors interactions, for instance E=ABC. To complete all the design, the basic design for the 4 independent generators 3^4 was first developed by using MINITAB software. Generators E, F and G were derived from the summation of three-factor interaction. A total of 27 scenarios were created based on the general rule of thumb of confounding (Montgomery, 1997) that is to confound the highest-order of interaction with blocks. All the main attribute effects were independent and orthogonal.

Table 2: Fractional Factorial Design

Mode of transport	Factorial design	Fractional Factorial Design	Factorial Effect
Car	3^7	3^{7-3}	A, B, C, D, E=ABC, F=BCD, G=ACD
Bus	3^{10}	3^{10-6}	A, B, C, D, E=ABC, F=BCD, G=ACD, H=ABD, I=ABCD, J=AB
Rail	3^9	3^{9-5}	A, B, C, D, E=ABC, F=BCD, G=ACD, H=ABD, I=ABCD

Figure 2 presents an example showcard of an SP choice scenario. Each respondent was presented with 2 different scenarios and was asked "if these travel options were available, which mode would you choose?".

27	**A : Travel by Car**	**B : Travel by Bus**	**C : Travel by Rail**
	In-Vehicle-time: **30 min**	Vehicle run every: **5 min** In-Vehicle-Time: **50 min**	Vehicle run every: **15 min** In-Vehicle-Time: **30 min**
	Petrol Price: **1.80 per litre** Toll: **RM 5 per day** Parking: **RM 12 per entry**	Fare: **RM 1.80 per trip**	Fare: **RM 1.70 per trip**
	Destination/objectives: **3 places**	Destination/objectives: **3 places**	Destination/objectives: **2 places**
	Security Level: **Medium**	Security Level: **Medium**	Security Level: **Medium**
		Walking Distance: **100 m**	Walking Distance: **250 m**
	Pollution due to vehicles : **High**	Pollution due to vehicles : **Medium**	Pollution due to vehicles : **Medium**
		Comfort Level: **Low**	Comfort Level: **Medium**
		Convenience Level: **Medium**	Convenience Level: **Low**

If theses choices were available, which would you choose?
Travel by Car ☐
Travel by Bus ☐
Travel by Rail ☐

Figure 2: Example of showcard

Besides the mode choice attributes, social-demographic characteristics of each respondent was also examined revealed preference (RP) survey. These characteristics include gender, age, income, occupation, level of education, vehicle ownership, monthly travel expenses and travel duration. The characteristics were described in more detail in Table 3.

Table 3: Mode choice case study variable labels

Variable Name/ Description	Labels
ID	Respondent ID
Gender (RP)	1 = Female 2 = Male
Race (RP)	1 = Malay 2= Chinese 3 = Indian 4 = Others
Age group (RP)	1 = 18 – 24 years 2 = 25 – 30 years 3 = 31 – 44 years 4 = 45 – 55 years 5 = > 56 years
Education level (RP)	1 = Primary 2 = Secondary 3 = College / tertiary
Occupation (RP)	1 = Student 2 = Technician 3 = Executive / administration 4 = Managerial / Professional 5 = Self – employed 6 = Retiree 7 = Others
Monthly income (RP)	1 = < RM 1000 2 = RM 1001- 1500 3 = RM 1501 – RM 2000 4 = RM 2001 – RM 3000 5 = RM 3001 – RM 4000 6 = RM 4001 – RM 5000 7 = RM > 5000
Total expenses (RP)	As per specified by respondent
In-vehicle time (SP)	As per Table 1
Headway(SP)	As per Table 1
Walking distance to public transport service (SP)	As per Table 1
Fare (SP)	As per Table 1
Cost for petrol (SP)	As per Table 1
Parking (SP)	As per Table 1
Toll (SP)	As per Table 1
Travel objectives/ accessibility (SP)	As per Table 1
Environment awareness (SP)	As per Table 1
Security level (SP)	As per Table 1
Comfort level (SP)	As per Table 1
Convenience level (SP)	As per Table 1

5. DATA CHARACTERISTICS

A total of 635 survey forms were collected but after screening, 44 incomplete forms were discarded. Table 4 and Table 5 show the distribution of respondents by gender and race respectively. Male respondents comprised of 50.6% and 43% of the total respondents were Malays. Chinese respondents composed of 34% followed by Indians, 18.3% and others, 4.7%

Table 4: Distribution of respondents by gender

Gender	Frequency	Percentage (%)
Female	292	49.4
Male	299	50.6
Total	591	100.0

Table 5: Distribution of respondents by race

Gender	Frequency	Percentage (%)
Malay	254	43.0
Chinese	201	34.0
Indian	108	18.3
Others	28	4.7
Total	591	100.0

Table 6 shows the distribution of respondents by age group. Based on Figure 6, most of the respondents (33.5%) aged between 31- 41 year old.

Table 6: Breakdown of respondents by age group

Age Group	Frequency	Percentage (%)
18 – 24 years	153	25.9
25 – 30 years	176	29.8
31 – 41 years	198	33.5
45 – 55 years	56	9.5
> 55 years	8	1.4
Total	591	100.0

Table 7 shows the distribution of respondents' income level. Based on Table 7, about one – quarter of the respondents earned between RM 2001 – RM 3000 per month.

Table 7: Respondents' income level

Income	Frequency	Percentage (%)
< RM 1000	86	14.6
RM 1001 – RM 1500	101	17.1
RM 1501 – RM 2000	96	16.2
RM 2001 – RM 3000	145	24.5
RM 3001 – RM 4000	77	13.0
RM 4001 – RM 5000	39	6.6
> RM 5001	47	8.0
Total	591	100.0

6. MODE CHOICE ANALYSIS

In this study, Multinomial Logit (MNL) model was used to represent the decision making procedure of an individual, in making a choice from a set of alternatives based on various influencing factors. The LIMDEP NLOGIT software was used to develop this model. As each respondent was presented 2 choice sets, there were a total of 1182 cases.

IN MNL, utility function for an alternative represents a linear equation corresponding to the functional relationship between various attributes with that particular alternative (Hensher et al., 2005). The basic form of utility functions for car, bus and rail used in the mode choice analysis are as follows:

$$U(car) = constant + \beta_1 car * variable\text{-}1 + \beta_2 car * variable\text{-}2 + \ldots \beta_n car * variable\text{-}n \quad (1)$$

$$U(bus) = constant + \beta_1 bus * variable\text{-}1 + \beta_2 bus * variable\text{-}2 + \ldots \beta_n bus * variable\text{-}n \quad (2)$$

$$U(rail) = \beta_1 rail * variable\text{-}1 + \beta_2 rail * variable\text{-}2 + \ldots \beta_n rail * variable\text{-}n \quad (3)$$

Based on the attributes listed in Table 3, the preliminary assumptions of the utility functions for the three modes are shown in equation (4), (5) and (6). Attributes related to socio-demographic characteristics such as gender, race, age, education level, occupation and income will be invariant across alternatives. This invariance means that the parameter for that particular variable cannot be estimated for each and every utility function within the model. Therefore, in order to establish some variance, parameters related to socio-demographic characteristics can only be estimated for n–1 alternatives where n is the number of alternatives in the model (Hensher, 2005).

$$U(car) = a_1 + a_2{*}GENDER + a_3{*}RACE + a_4{*}AGE + a_5{*}EDU + a_6{*}OCCU - a_7{*}INCOME - a_8{*}CST - a_9{*}PARK - a_{10}{*}TOLL - a_{11}{*}IVT_{car} - a_{12}{*}EXPRP + a_{13}{*}OBJ_{car} + a_{14}{*}ENVIRON_{car} + a_{15}{*}SECURITY_{car} + a_{16}{*}COMFORT_{car} + a_{17}{*}CONV_{car} \quad (4)$$

$$U(bus) = a_{18} + a_2 GENDER + a_3{*}RACE + a_4{*}AGE + a_5{*}EDU + a_6{*}OCCU - a_7{*}INCOME - a_8{*}FARE_{bus} - a_{11}{*}IVT_{bus} + a_{13}{*}OBJ_{bus} + a_{14}{*}ENVIRON_{bus} + a_{15}{*}SECURITY_{bus} + a_{16}{*}COMFORT_{bus} + a_{17}{*}CONV_{bus} - a_{19}{*}HEADWAY_{bus} - a_{20}{*}WALK_{bus} \quad (5)$$

$$U(rail) = - a_8{*}FARE_{rail} - a_{11}{*}IVT{*}_{rail} + a_{13}{*}OBJ_{rail} + a_{14}{*}ENVIRON_{rail} + a_{15}{*}SECURITY_{rail} + a_{16}{*}COMFORT_{rail} + a_{17}{*}CONV_{rail} - a_{19}{*}HEADWAY_{rail} - a_{20}{*}WALK_{rail} \quad (6)$$

where

GENDER	=	Gender
RACE	=	Race
AGE	=	Age group
EDU	=	Educational level
OCCU	=	Occupation
INCOME	=	Monthly income
CST	=	Cost for petrol
FARE	=	Fare
PARK	=	Parking
TOLL	=	Toll
EXPRP	=	Total expenses
OBJ	=	Travel objectives/ accessibility
ENVIRON	=	Environment awareness
SECURITY	=	Security level
COMFORT	=	Comfort level
CONV	=	Convenience level
HEADWAY	=	Headway
WALK	=	Walking distance to public transport service

Several models were run and the results of the best fitted model were presented in Table 8. Attributes related to socio-demographic characteristics such as gender, race, age, education level and occupation was found to be statistically insignificant except income level which was found to be significant in explaining the mode choice behaviour. This is consistent with the findings by various researchers such as Pendyala et al. (1995) and de Palma and Rochat (2000). Other attributes such as environmental awareness, comfort and convenience were found to be statistically insignificant for all mode choice. Apart from that, parking and toll were also found to be statistically insignificant for mode choice car while headway was found to be statistically insignificant for both mode choice bus and rail.

Table 8: MNL results

Attribute	Coefficient	T - statistic
Alternative-specific constant for car (a_1)	-0.5687	0.0048*
Income (a_7)	-0.1591	0.0000*
Cost/ Fare (a_8)	-0.0729	0.0169*
In-vehicle time (a_{11})	-0.0079	0.0014*
Total expenses (a_{12})	-0.0035	0.0000*
Travel objectives/accessibility (a_{13})	0.1460	0.0014*
Security level (a_{15})	0.1679	0.0005*
Alternative-specific constant for bus (a_{18})	-0.2197	0.2209
Walking distance to station (a_{20})	-0.0011	0.0014*
Log likelihood (LL) function	**-1104.67**	
R-squared (R^2)	**0.4284**	

* significant at 5 %

The utility functions based on the results in Table 8 were reproduced as follow:

$$U\ (car) = -0.5687 - 0.1591^{*}INCOME - 0.0729^{*}CST - 0.0079^{*}IVT_{car} - 0.0035{*}EXPRP + 0.1460^{*}OBJ_{car} + 0.1679^{*}SECURITY_{car} \quad (7)$$

$$U\ (bus) = -0.2197 - 0.1591^{*}INCOME - 0.0729^{*}FARE_{bus} - 0.0079^{*}IVT_{bus} + 0.1460^{*}OBJ_{bus} + 0.1679^{*}SECURITY_{bus} - 0.0011^{*}WALK_{bus} \quad (8)$$

$$U\ (rail) = -0.0729{*}FARE_{rail} - 0.0079^{*}IVT{*}_{rail} + 0.1460^{*}OBJ_{rail} + 0.1679^{*}SECURITY_{rail} - 0.0011^{*}WALK_{rail} \quad (9)$$

The signs associated with the study variables were correctly representing the utility that an individual choose. People would get out from their mode and look for alternative if the travel time increases. The significance found for walking distance suggests that proper design of public transport stations would encourage people to take public transport service. The signs associated with the monetary related variables reflect that the higher the value the less likely the people continue with their mode of travel. Integrating transportation planning, land use development and communities would effectively change the travel pattern which is found significant (travel objectives with t-value 0.0014).

7. VALUE OF TIME ANALYSIS

Apart from the mode choice analysis, analysis to determine the value of time (VOT) was also investigated. An interview survey was conducted and respondents were presented with two sets of SP choice sets with different combinations of factor levels. In this analysis, the effects of time and cost on commuters were examined. Table 9 presents the MNL results from SP survey for those who chose car and bus with reference to the rail mode. Waiting time is not applicable to car mode as car driver can depart at any time.

Table 9: MNL results from SP survey on value of time

Attribute	Car		Bus	
	coefficient	t-value	coefficient	t-value
Constant	0.3826	0.4135	-1.0714	0.0000*
Cost	-0.0436	0.0021*	-0.1919	0.0524*
In-vehicle time	-0.01197	0.0000*	-0.001725	0.7192
Waiting time	-	-	-0.009259	0.0568*

* significant at 0.1

All the signs for the coefficients were found to be correctly representing the situations of which the increase in cost and time are all undesirable. The mode constant for car mode chosen is positive indicating the car is always the preferable mode while bus is less favourable as compared to rail.

In order to determine the effects of time and cost for those travelling with car and bus with the reference to rail, VOT was computed by dividing each time parameter by the cost. The results were presented in Table 10.

Table 10: Monetary valuations form the SP mode choice

Value of Time	Car	Bus
Value of in-vehicle time in RM/hour ($VOT_{in\text{-}vehicle}$)	16.20	0.54
Value of waiting time in RM/hour ($VOT_{waiting}$)	-	2.88

Based on the results obtained in Table 10, value of in-vehicle time, $VOT_{in\text{-}vehicle}$ for mode choice car is very high as compared to the bus mode. This indicates that those who prefer cars were more concerned with the time spend in their cars as compared to those who prefer bus. This is true as those who commute using private vehicles are more sensitive to the time and are willing to pay more in order to arrive on time. As for the VOT for bus, the value of waiting time, $VOT_{waiting}$ is higher than the value of in-vehicle time, $VOT_{in\text{-}vehicle}$. This is a fairly typical result as a reduction in waiting is seen to be of higher importance than reduction in in-vehicle time. This is because bus users tend to get anxious and upset if they spent a long time waiting for the bus to arrive but not so if they have to spend a long time in the bus.

8. CONCLUSION

In this paper, the mode choice (car, bus and rail) behaviour in Klang Valley was examined through stated preference approach. Attributes studied were identified based on the concept of sustainable transportation. Travel objectives or accessibility and walking distance to public transport services were found significant in modal split choice and this suggest the importance of integration design of transportation plan, communities and land use planning. Travel time and travel cost results are in consistent with other findings with their influence in mode choice.

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